ENGINEERING EDUCATION

Bulletin of the

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee.

P. F. Walker, Chas. F. Scott, F. L. Bishop, *Editor.*

The following, Chairman of committees, are by action of the Council Co-operating editors.

E. J. Berg,	W. S. Franklin,	W. T. Magruder,
R. M. Bird,	C. H. Fulton,	J. R. Nelson,
H. S. Boardman,	W. K. Hatt,	W. G. Raymond,
G. M. Butler,	D. C. Jackson,	J. W. Roe,
H. E. Dyche,	J. O. Keller,	G. C. Schaad,
J. T. Faig,	R. S. Kirby,	E. C. Schmidt,
O. J. Ferguson,	O. M. Leland,	A. C. Willard.

Vol. XIV Lancaster, Pa., January, 1924 No. 5

TABLE OF CONTENTS.

Industrial Coöperation in Engineering Education. P. F. Walker, President 214
Dinner at the Annual Meeting of the American Society of Mechanical Engineers 218
Joint Conference on Engineering Education 224
Minutes of Meeting of Deans and Administrative Officers, Cornell Meeting 225
Program and Information, Meeting of Deans and Administrative Officers, University of Michigan 241
Methods of Teaching Engineering Drawing. F. G. Higbee 243
Psychology in Drawing. Morris Wenk 249
Correlation Coefficients. Edwin Kurtz 257
Purdue Branch 260
Addresses Unknown 262
Book Reviews 263

INDUSTRIAL COÖPERATION IN ENGINEERING EDUCATION.

BY P. F. WALKER,

President of the Society.

Engineering education is a result of the development of economic thought of the world during the last 75 years. The influences which have attended its growth are markedly different from those which have had bearing on colleges of arts and sciences.

Civic and industrial development during these years has been demanding more and more of the application of scientific principles in the solution of constructive problems. It is this which has opened up the opportunities for men who have been trained along these lines, and to meet this demand the engineering schools have passed through a development process which has no equal in educational circles. The question sometimes arises as to whether this relationship in needs should be extended to embrace coöperation in action, whereby schools and industrial organizations should work out together the program for supplying the need. Will such coöperation endanger academic freedom?

Before the point can be treated fully it is necessary to define the terms that will be used in expressing the basis of possible action. The motive must also be clearly in view. The term *"industrial organization"* is susceptible of various interpretations. As here used we include all agencies, public and private, engaged in activities which lead to production of goods or permanent structures for either private consumption or public use. With this interpretation almost every activity entering into the modern economic system, under which people of civilized nations are living and working, are included. Very much of all that is being done to minister to the needs and comforts of people of today, whether it be in the lines of

consumable commodities, transportation, communication, or public service, is being produced through activities which involve engineering skill. In preparing men to meet the needs of these industrial activities the schools are thus rendering a direct service to humanity. It is in this broad outline that we desire to view the question.

There is a difference in scope and motive, also in the training of men to enter such activities. One kind of training has as its object the fitting of men to become immediately useful to the specific enterprises on which they embark. This is the aim of the trade or mechanic arts school. Another has for its object the training of men who may become competent to deal with problems of industry, and ultimately to render service, the character and significance of which may be quite different from anything which earlier connection with industry would indicate. The educational institutions represented by the membership of the S. P. E. E. are generally assumed to be dominated by the ideals represented by the latter statement.

Most of us will agree that educators must understand the needs of the service for which men are being prepared. It is as obvious a fact as that a manufacturer must understand his market. Possibly there are some who will not, holding rather to the tenet that an educator should not consider anything excepting the mental development of his students and the complete treatment of his branch of learning, but they are not to be found, usually, on our engineering school staffs. Even in the liberal arts divisions of our universities the possibility of training for a life of service in specific lines, at the same time that mental training is going on, is being admitted. Thus has the influence of professional schools—medicine, law, engineering—extended into the field of general education.

More and more insistently are questions being asked as to where we are tending in the field of publicly supported education. Schools are growing to sizes undreamed of a generation ago. The pressure starts at the high school. Public sentiment is approaching the point where an answer is demanded as

to the aims of and the justification for the extensive plants created in our institutions. It is an influence to be reckoned with in the future. The schools are being invited to address themselves to the question of motive and their impact on present-day life. If unheeded the invitation may be converted later into stronger phraseology.

Thus has it come about that educators and industrial leaders have begun to consider together the problems of training men in the lines of engineering and commerce. The future welfare of this country will be conditioned by its producing power in industrial lines rather than in raw materials from the farm and forests, and by its ability to hold its place in the markets of the world. For these ends it is necessary to have a trained personnel. It is highly important that the educational program be adjusted along broad lines to meet the requirements. To accomplish this there must be full understanding of the situation as it has been developing under the guidance of strong, forward-looking business men.

Three avenues of approach have already been opened for consideration of the question, in all of which S. P. E. E. has had a part. One is functioning through the National Industrial Conference Board, with its representatives from the ranks of educators and of business men. Another is through the national professional engineering societies, with activities centering largely in the conference committee of S. P. E. E. The third was in the series of conferences called by the federal Bureau of Education, three of which were representative gatherings devoted to the task of defining a common meeting ground.

Any educator whose tendency is to fear encroachment of industrial interests on the domain of education should have been present at these several conferences. The experience would have caused him to open his eyes to a new light. The dominating note has been the advocacy of breadth and thoroughness in the educational program, and the men who have sounded this note most emphatically have not been the educators but responsible officials of great industrial corpora-

tions. It had been an inspiration to hear the men whom some would assume to be animated by desire to have engineers trained in the schools along specialty lines for corporate interest, argue forcefully for sound basic training that lays the proper foundation for growing men who are preparing for lives of greatest service. No, it is not the responsible industrial leader who is to be feared as an influence inimical to sound educational doctrine. Their help is needed, rather, so that those of us who are bound in some degree to the routine of the school may understand better the needs of the service for which students are being prepared. The faithful men in the schools have accepted a stewardship at the hands of the public that is supporting educational institutions. They are responsible to the youth who fill their classrooms. In a measure not always recognized by themselves they are building for the future of the nation. They need all the help that is available.

While this line of thought was not projected for the purpose, it should not be dropped without the remark that the investigation now beginning under our own Board of Investigation and Coördination, with the support of the Carnegie Corporation, is a fourth avenue to approach to the problem of adaptation. It can be made the most significant of all if every member of S. P. E. E. unites in the work whenever and wherever opportunity offers.

DINNER AT THE ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

On Wednesday evening, December 5, during the annual meeting of the American Society of Mechanical Engineers, a group of educational representatives held an informal dinner at the Engineers' Club. Thirty-five persons, representing institutions in eighteen states, extending from Maine to Texas and Oregon, gathered on the initiative of Prof. W. T. Magruder, past president of the S. P. E. E., who acted as chairman. Prof. C. F. Scott and Prof. D. C. Jackson of the Board of Investigation and Coöperation were present and spoke briefly on the inception and scope of the Board's work.

Professor Magruder then introduced the guest of the evening, Mr. W. E. Wickenden, the newly appointed Director of Investigations, who discussed the program of investigation which the Society is about to undertake. As the Board had not at that time formulated its program in detail Mr. Wickenden indicated the probable scope of the inquiry in a series of questions. He said in part:

From various hints that come my way I suspect that you who are present as well as the great group of engineering teachers who are back home working at it, are full of questions about this project. "Haven't we had an extended inquiry into engineering education—why another? Aren't things reasonably satisfactory? Does not the brisk demand for our graduates and their ever-rising record of accomplishment testify to the excellence of their training? This project is said to be a movement of the colleges themselves. What are we expected to do about it—haven't we more than enough to do already?"

I shall offer no other justification for the project than the vast number of things about engineering education that we do not know. Consider first the *student*. What kind of a young human animal is he? With what hereditary endow-

ment did he start; what was his early environment; to what extent does he represent the rural background with its abundance of life in the open, wholesome discipline, familiarity with tools, experience in contriving expedients, in making emergency repairs and contact with animal life; to what extent is he of the race of urban cliff-dwellers, highly sophisticated in the ways of the crowd, but without the benefits which come from being chief engineer of a heating plant or chief navigating officer of a lawn-mower?

What brings him to the college of engineering, what does he hope to find there, and what does he hope to accomplish there? Did he have any adequate counsel as to what engineering is and what exactions it makes in the realms of body, mind and character? To what motives can we appeal in order to inspire him and what influences are likely to dull the edge of his zeal?

What kind of a mind does he bring, and what are its normal thinking processes? Are his conceptual powers strong, does he generalize readily and work out to particulars by a deductive process? Does he learn most readily through words and other symbols, or through the cumulative effect of orderly concrete experience? Do we know what material we want, or ought to want, our admission systems and our systems of sifting and elimination to select for us and how well they do it?

Consider next our *teaching*. Suppose that we do know what kind of a young human animal the engineering student is, do we know how that kind really ought to be taught? Are we teaching young men, or subject matter? From the viewpoint of the student's motive thinking processes are we right in giving him first the great generalizations of mathematics, physics and chemistry, or should we plan our teaching to build up to these at the end? Should we or should we not segregate our students into groups according to their academic records—may not such records indicate a special aptitude for making recitations and writing examinations rather than real power?

Do we know whether the traditional divisions of the engineering curriculum are really significant and whether the students are distributed among them intelligently, or not? What are the merits and demerits of Professor Bennet's alternative of curricula worked out according to functional divisions of activity?

Are we teaching too didactically, too much from books and too much from artificially simplified problem material, and ought we to borrow more from the "case system" with actual engineering problems? Are we too preoccupied with the physical ways and means of engineering and too little concerned with its economic philosophy and processes?

Is the four-year course too long for some and too short for others, a compromise satisfactory to nobody? Are engineering colleges conceding too much in order to provide training to men who ought to have gone to specialized vocational schools of intermediate grade? Do more men need post-graduate work, and if so, what sort of men and what sort of work? Is cooperative work a local problem or should it be adopted far more widely?

Let us also consider our *teachers,* even though we run the risk a bit personal. How are they obtained and what is their training in the art of teaching? How many of them drift into the work by inadvertence and remain because they find it awkward or uncomfortable to change? What qualifications should we wish them to have and who should be responsible for the development in them of such qualifications? Is there status one of prestige and economic independence, really worthy of the choicest men of the profession? If not, what can be done to recover or create such a status? How should teachers be given recognition and advancement and should these be dependent primarily on reputation outside of academic walls? What inducement is there, if any, for a man to strive seriously to perfect himself in the art of teaching?

Consider also our *product.* Are we endeavoring to produce embryo engineers or soundly educated young men? Is it an occasion for regret or for satisfaction that so many engineer-

ing graduates enter upon other fields of work? Should we assume that the engineering college is primarily a professional school? Whether we do or do not, what are engineers; in what degree are they individual practitioners, industrial technologists, industrial administrators, members of consulting groups, public officers and dealers in merchandise or service? What are their functions, what matters are put up to them for recommendation or decision, what kind of evidence do they gather, what methods of analysis do they use, and what are the criteria of their decisions?

How fully should the attributes of the engineer be reflected in the engineering curriculum? What part of the training needed in developing an engineer can be given effectively in college and what part in practice? Recognizing as we all do that the college cannot complete the training of an engineer and that part of its task is to give sound training to many who never will become engineers, what share, if any, should the college take in carrying out the training of the engineer which lies beyond graduation? Are the conditions which surround the graduate in his years of professional novitiate favorable to the development of the habit and power of self-education? In the last analysis will not that institution succeed best which turns out the largest proportion of active and effcient self-educators?

How is the product of our engineering colleges distributed after graduation? Are the present means of counsel, guidance and contact with opportunity adequate and wise, or is too much left to chance? Are graduates reasonably paid and given adequate opportunities, are they neglected, or are they exploited? Do they need better training in the art of marketing their services?

Consider also our *institutions*—the colleges themselves. Should they be more alike or less alike? To what degree should they reflect their economic and professional environment? Should they operate on the principle of the common carrier and admit the obligation to take all the freight that is properly classified and can pay its way? Is there a law of

diminishing returns which should impose limits to their size?

Who shall foot the fast mounting bill for operating expenses —shall society assume it by taxation, shall greater endowments be sought from men of wealth, shall industry be asked to assume a larger share of it or shall it be charged in larger measure to the student himself as the chief beneficiary? Should we encourage a wide-spread adoption of the coöperative plan as a means whereby both the student and the college may more nearly balance their budgets as they go?

Consider also the *extra-curricular life* of our colleges. What educational values may we assign to athletics, dramatics, literary and editorial effort, managerial experience and the elective offices of college life? Are these activities worthy to be weighed in the same scale with scholarship? What values inherent in the rich institutional life of the older liberal colleges ought we to seek to transplant to the engineering schools? What means of spiritual, æsthetic and humanistic inspiration should be provided for engineering students? Is there a liberalizing profit in sharing the varied interests of a university life which balances any loss in intensity of effort, as compared with segregated schools of engineering?

Who ought to be studying these matters? The educators, of course, the men who are doing the job. Can they do it singly, or can single institutions do it, or can the educators just as a group by themselves do it? Every one of these can do an exceedingly valuable part but neither one nor all of them can do the whole job. Engineering education is too complexly interwoven with industry, with professional life, with business, and with public administration to be dealt with as a thing by itself, hence the need for broad vision and comprehensive coördination in any basic study of the field.

Educators have a reputation for being highly individualistic and educational institutions for being jealous of their independence. When some 1,700 individual educators and a hundred or more colleges of engineering united under the leadership of the S. P. E. E. for a project of self-study and self-improvement, I was greatly interested; when they under-

took to call in for counsel the representatives of the engineering professions, of industry, of business, and of public administration, I was greatly impressed; and when I was offered this opportunity for active service under the Board of Investigation and Coördination, whose members I had come to know, to admire and to love, I confess it made an irresistible appeal to my imagination.

For a time at least, our task must be largely one of fact-finding. If engineering education could be saved by rehearsing accepted truisms and obvious generalities, by piling up unconstructive criticisms, or by reciting pious resolutions, it would have been not only saved but wholly sanctified long ago. What we need at the moment is more facts, more of the kind of evidence that underlies good engineering analysis and planning. It is our hope that the principal part of this fact-finding process will be carried on by the colleges themselves through coöperating committees, The University of Michigan has led off in this matter and other institutions are appointing their own committees without waiting to be prompted. Knowing a little of the great record of the A. S. M. E. in all matters of coöperation in the broader field of engineering, I am confident that this group and your departmental colleagues back home will claim a place of leadership in the enterprise.

JOINT CONFERENCES ON ENGINEERING EDUCATION.

The success of the informal dinner held in connection with the annual meeting of the American Society of Mechanical Engineers has prompted arrangements for similar gatherings at the principal winter meetings of the national engineering societies. A suggestion to this effect from the Board of Investigation and Coördination has been accepted with great cordiality by the American Society of Civil engineers, the American Institute of Electrical Engineers and the American Institute of Mining and Metallurgical Engineers.

The next conference of this series will be held in conjunction with the annual meeting of the A. S. C. E., on the evening of January 17th, at the Engineers' Club in New York. To avoid interference with the evening session of the convention the hour has been set at 5:45 P. M. Messrs. C. F. Scott, D. C. Jackson and W. E. Wickenden will speak briefly of the inquiry into engineering education which this society is undertaking. Members of the S. P. E. E. in attendance at the convention are urged to attend this conference.

Arrangements will be made for a similar conference at the mid-winter convention of the A. I. E. E. to be held in Philadelphia early in February. If practicable this meeting will be held on the same day as the dedication of the new Moore School of Electrical Engineering which is expected to draw a large attendance of educational representatives.

The American Institute of Mining and Metallurgical Engineers will hold its annual convention in New York on February 18 to 20, inclusive. Arrangements for a joint conference during this convention are being made and will be covered by a later announcement.

MINUTES OF MEETINGS OF DEANS AND ADMINISTRATIVE OFFICERS, JUNE 22–23, 1923, AT CORNELL UNIVERSITY.

DEAN WM. G. RAYMOND,

Chairman.

Mr. Raymond: During the past year, President Scott asked Deans Cooley, Hitchcock and Raymond to act as a Committee for a program for this meeting. We sent out many letters, asking for suggestions, and many topics were suggested for discussion. There were two topics which came from more than one person and these two we have adopted for discussion at the two sessions of this Division of Deans and Administrative Officers. One was "How to Improve our Teaching," and the other, "The Longer College Course for Engineers."

Recently I read a very interesting report of a university chancellor, and wrote to him asking for several copies to distribute among my faculty. Last winter at a gathering of men in our town I heard the same chancellor say some things that appealed to me. It occurred to me that the gentleman who wrote this report, and who said the things I heard that evening would be an excellent person to open our discussion on Methods of Improving our Teaching, and so I have asked Chancellor J. G. Bowman of the University of Pittsburgh, to open this discussion. Dr. Bowman then addressed the conference without manuscript, calling attention to the need for pleasant and suitable surroundings, and personal interest on the part of the instructor in each student.

Discussion.

A. M. Greene: When Dr. Bowman stated that he had not said much I thought of the story of the mayor's wife.

I would like to express to Dr. Bowman my appreciation of

what he has said concerning two things, the matter of self-examination, and the matter of personal interest. I think if we are to improve our teaching these two items must be uppermost at all times. Are we doing the best we can? Can you go away from a class and think, 'I have given the class the best in me?' I cannot always say that. I am afraid we do not ask that question enough. There must be personal contact. This is necessary in industry and in our work. At Princeton we have one of our former trustees interested in this idea that Dr. Bowman suggests. It is a reality in one institution. Send out our teachers into the world to gain contact. A gentleman gave to the Engineering Department a sum of money to be used during a period of four years. We could use it for one man for one year or for four men for four summers. This money is given to a man so that he may get out and form contact with industry and engineering. The only restriction is that the man remains in teaching, not at Princeton necessarily, but we want him to use that experience for the benefit of teaching engineering. We hope that when the sum is used up in four years it will be repeated. One of our men this year is abroad for 7 months.

F. W. McNair: My first reaction was different from that of Dean Greene. The Chairman of this section is to be patted on the back for his choice of a speaker. This talk at first depressed me. He has in his skillful command of the English language held up before us an ideal, an ideal which is so far beyond some of us either with the teaching we are personally doing, or teaching we are getting from members of our staff, that I am depressed. I do not condemn his ideal, and, turning it around, it is good for us to run up against something like this and see how far away we are from doing that which should be done. I am discouraged when he talks about selling it to our community. As you may know, I am connected with a state institution. I see other gentlemen who are in some respects like myself. The legislature has been in session, and part of your selling job and mine is to take some of these things to a legislative committee. I am asking you is it rea-

sonable to expect us to make an address to a legislative committee comparable to the one that Dr. Bowman has made to us, and expect it to go over as a sale?

I am inclined to present some of the difficulties of the other side of the picture, and to say that while I do think it is a good thing for us in executive positions to hear such an address, I do think our teachers should hear it too, particularly the part about our students being individually our own. The problem which faces us is some detail of this thing, and the teacher is apt to come to us having seen some ideal, and say, 'I am a failure; I just can't do it.' You inquire what the trouble is, and he talks freely, and he tells you he made some effort with the men, and he failed. He did not get across with the men. He gave them written quizzes, and they were many miles away. You had to take that man, and tell him some of your own failures in early teaching. You can match his failures with yours. That is very helpful. I wish we could take the Chancellor's suggestion, and get rid of every teacher who does not have vision. I think perhaps we could get rid of them, but I do not see how we can replace them.

Salary looms large in state institutions, and in some cases shuts off the ideals he presents.

P. F. Walker: I am very glad that Dr. Bowman touched on the point of atmosphere in the class room. I think that the formalized arrangements which are characteristic of our rooms has greater influence than we fully appreciate. I cannot help but think that there is one question and that is honesty. There are always cases of dishonesty. I believe that we may do some things to better the situation and appreciate at least this phase of the ideal program of the situation which Dr. Bowman has presented. I want to speak of an experience of my own. I have tried it for two years, and would not give it up. There was a group of 24 or 25 upper classmen in this particular line of work. I brought them into my office, a large room. Around the table chairs were arranged. Every man was comfortable. Every man has a place at the table. In every respect arrangements were those for a meeting of a

board of directors, and then we got into the subject. The men talked to each other and they worked on whatever the problem might be. I am not sure but what we might get closer to doing that in other respects in classes we may not want to bring into our offices. It will help break down the barrier of formality that is really a serious thing. I have enjoyed this talk by Dr. Bowman. It has done us all a world of good.

D. C. Jackson: I have been very much impressed by what Dr. Bowman has said and do not depreciate its great weight, but I would regret very much too much weight being placed upon the mere influence of surroundings in class rooms and lecture rooms. We can have the students discussing their class problems in ordinary class rooms just as well as if they were seated in easy chairs. It seems to me that it is part of the duty of the teacher to accomplish this, and that failure to provide easy chairs and pictured walls is not a ground for excuse in case he fails in this part of his duty. The real question is whether the teacher is sufficiently interesting and sufficiently full of his subject when he goes to his teaching, so that he may accomplish the desirable end. It is not so much a question of surroundings as it is a question of the man,—namely, the teacher. Satisfactory surroundings help the man but it would be a most unfortunate thing to implant the idea in the engineering schools, or any other seats of higher education, that good teaching depends largely upon surroundings. I think we can all of us remember student days in which we attended lectures or quiz classes in rooms which were even more unharmonious and discouraging than the room in which we sit, and yet certain of these lectures and quizzes made a tremendous impression upon our intellectual growth. The influence of reasonable comfort is great, to be sure, but the influence of the man is far greater, and that is the thing which we must particularly stress in order to secure what we aim at.

P. F. Walker: I am glad that Professor Jackson brought out this subject. I do believe that we need to do something to break down that formality that students have grown to as-

sociate with the class rooms. I cannot help but remember that it is not the discomfort, but just the stiffness that has given so many students the attitude of opposition.

M. E. Cooley: I could not help thinking while listening to Dr. Bowman of our experiences at the Naval Academy. In our sleeping rooms we could not have anything on the wall. You had to hang the picture of your mother on the inside of the cupboard door. When you complained to your instructor that you did not get his lecture or did not understand the question the reply was "I do not give a damn whether you understand it or not. I am here to teach you and find out what you learn." That is an illustration of what you might call brutality. It does something. It teaches the man self-reliance. It stirs up in him a pride. That self-reliance puts the thing over and great results are gained. Text books are all right. . . . You can take one or another. That, Dr. Bowman, is education of the man in the school, development of the man and we are not doing that today.

Wm. G. Raymond: I think the Committee is to be congratulated. It is a good thing to be depressed some times. When we think everything is going all right is a pretty good time to look for something that is wrong. The first step is to have somebody bring to us the fact that something is wrong. The next step is to make it right. The teacher is in trouble and thinks he is a failure. There is a little more hope for that fellow than for one who thinks he is o. k.

The Council of the Society in session yesterday considered the project of the Board of Investigation and Coördination and has sent a proposed resolution to this Division of the Society with the request that we consider it; it is as follows:

The Division of the Society for the Promotion of Engineering Education, composed of Deans and Administrative Officers of engineering schools and colleges, having before it the proposed program of the Board of Investigation and Coördination for the conduct of its work, approves that program unreservedly and pledges its support to the Board and its en-

deavor to secure such individual and united faculty coöperation that may be desired by the Board.

A. A. Potter: I move that we accept the resolution without reservation and get in back of the spirit expressed in this resolution. Motion carried.

Wm. G. Raymond: The committee on program for this meeting was appointed by President Scott. For next year we might choose our own chairman.

Moved that nominations for chairman be presented. A. M. Greene's name was presented and upon motion the nomination closed. He was unanimously elected chairman for the meeting in 1924.

M. E. Cooley: Should we have more than one meeting of this Division? President Burton has given three invitations to meet at Ann Arbor.

A. A. Potter: It is very desirable to have a winter meeting in order to discuss progress of the Board. I move that we have a winter meeting. Motion carried.

The program for the meeting left to a committee of three and Dean Greene given power to appoint the other members of this committee.

O. M. Leland: I move that we accept the invitation of President Burton and hold the winter meeting in Ann Arbor. Motion carried.

The chairman of this meeting is to express the appreciation of the Deans to President Burton.

Meeting adjourned.

SECOND MEETING OF DIVISION OF DEANS. JUNE 23, 1923.

Dean Raymond called the meeting to order at 8:45 A.M.

The first thing considered was the number of sessions for next year. Dean Greene moved that two sessions be held. Motion carried.

Dean Cooley then addressed the Division on the Five Year Course in Engineering. He presented the following majority and minority reports of the Committee on Revision of Curricula of the Engineering College of the University of Michigan.

MEETING OF DEANS AND OFFICERS.

UNIVERSITY OF MICHIGAN,
ANN ARBOR.

November 24, 1922.
Majority Report.

TO THE FACULTY OF THE
COLLEGE OF ENGINEERING.

Gentlemen:

1. Your Committee has just completed a series of meetings held since the opening of this school year to finish, so far as possible, its work of last year on the consideration and devising of five-year programs or curricula in Engineering. During these meetings certain principles and common requirements were decided upon for the guidance of each of the members of the Committee in the making up of his individual curriculum. Since your approval of the curricula will probably be based on your agreement or disagreement with these principles and requirements, they are given herein as follows:

A. That these five-year courses do not necessarily contemplate a degree at the end of the fourth year.

B. That the first year of the five be identical with the first year of our present four-year courses.

C. That the first two years of the five be identical for all curricula. These two years are as follows:

FIRST YEAR.

First Semester.	Hrs.	*Second Semester.*	Hrs.
*Group *A*	4	*Group *A*	4
Draw. 1	3	Draw. 2	3
Math. 1	4	Math. 2	4
Eng. or Chem.	4 or 5	Chem. or Eng.	4 or 5
	15 or 16		15 or 16

SECOND YEAR.

First Semester.	Hrs.	*Second Semester.*	Hrs.
*Group *A*	4	*Group *A*	4
Math. 3	4	Math. 4a	4
Physics 1	4	Physics 2	4
Ch. E. 1	3	E. M. 1	4
Shop 2	3	Draw. 3	2
	18		18

*(Languages, History, Sociology, Biology, Geology.)

D. That each of the specialized curricula embody the following common requirements:

	Hrs.		Hrs.
Physics	12	Drawing	8
English	9	Engr. Mech.	7
Language	16	Surveying	3
Mathematics	16	Shop	3
Economics	4	Ch. E.	3
Cult. Elect.	3	E. E.	4
Chemistry	5	M. E.	4
		Total	97

E. That the fifth year constitute to a large degree a year of professional work, but that it not carry the student materially beyond the work of his present fourth year.

F. That the additional 34 hours added to the 140 hours of the present four-year curricula be devoted largely to such subjects as will enable the graduates under such curricula to develop to the maximum and serve to the maximum efficiency in the constantly broadening field of engineering.

2. The Department of Chemical Engineering deems it necessary to have a sequence in their studies in chemistry as makes it apparently impossible for them to agree to the common two years as outlined under *"C"* above. The majority of the Committee has been unable to comprehend the necessity for this in considering a five-year program only and has therefore framed paragraph 1-*C* as given. There is a feeling on the part of some members of the Committee that a concentration on the fundamentals of engineering—that is, physics, mathematics, mechanics, etc.—to the conclusion of chemistry would be quite beneficial to these men whose primary interest normally is chemistry and whose tendency is, therefore, to slight to a degree other subjects than chemistry. The Department of Chemical Engineering is appending to this report a minority report.

3. Some of the members of your Committee doubt seriously the wisdom of attempting to arbitrarily substitute these five-year curricula for our present four-year curricula, and feel that a very vigorous and well thought out campaign is necessary to convince not only our students, but their parents as well, that it is desirable to spend this extra year in obtaining a broader education. It is felt that any attempt to replace the present four-year curricula with these five-year courses might result in a diverting of a large percentage of our students to other schools which may not for some time follow our example.

4. In support of "*A*" under paragraph 1 above, that these curricula do not necessarily contemplate a degree at the end of the fourth year, it may be desirable to explain that your Committee was instructed by faculty action of June 2, 1922, to devise a five-year curriculum in which the first two years of the first four years would be common to all except Chemical Engineering. This action apparently contemplated a relatively complete four-year curriculum, at the end of which time a degree would probably be granted and beyond which many students would not take further work in this College. The committee has found it impossible so far to devise any four-year curricula, even though they be considered only the first four of the five-year curricula, in which the first two years are common. The Committee therefore ceased its attempts to devise a combination four- and five-year course, with the first two years common, and concentrated its efforts on a five-year course only, with the understanding that our present fourth year of work—with slight modifications—would constitute the new fifth year.

5. In moving the present fourth year work into the fifth year with slight modifications, it is found that the four previous years do not seem to round out to such an extent as would warrant a degree or as would bear examination in the eyes of students and parents in comparison with either our present four-year curricula or those of other schools. It seems reasonable that the first four years do not necessarily constitute a completed job for which we can grant a diploma since it is merely our desire to broaden our present course in engineering without attempting to carry the student materially farther in his professional work. If the faculty sees any solution of this problem that differs from that of the Committee, it might lessen the difficulty in putting these new curricula into effect.

6. Your Committee feels that in the event that we attempt to put into effect these five-year curricula while administering the four-year courses, it should be our policy to persuade only those men who have demonstrated their superior qualifications at the end of the first year to take up the five-year program. We are not sure but that it would be wise for men of all calibres to work under these five-year programs, but as long as we attempt to maintain both four- and five-year courses it would seem wiser to place a premium on the longer courses, thereby building up a very desirable reputation for them and strengthening their appeal to future students.

7. Since some of the members of your committee feel it unwise to substitute the five-year for the present four-year curricula until a number of major engineering colleges agree to inaugurate similar

curricula, we are giving below our suggestions in the form of resolutions to cover the temporary disposition of this report.

Respectfully submitted,

H. W. MILLER,
H. C. SADLER,
BENJ. F. BAILEY,
CLARENCE T. JOHNSTON,
H. C. ANDERSON,
H. E. RIGGS,

Committee on Revision of Curricula.

1. *Resolved:* That the Faculty of the College of Engineering approves the report of the Committee on the Revision of Curricula dated November 24, 1922, with the understanding that this new program does not take effect until a substantial number of major engineering schools are prepared to adopt a similar curriculum.
2. *Resolved:* That the Dean be requested to take such action as he deemed advisable to communicate this program to other engineering schools and to urge their adoption of a five-year course similar in principle to this, and that he report progress from time to time to this faculty.
3. *Resolved:* That the various members of the Committee who are heads of professional departments be instructed to complete the curricula of their individual departments and present them to the Dean for entry on the records of the faculty.

UNIVERSITY OF MICHIGAN,
ANN ARBOR.

November, 27, 1922.

Minority Report.

TO THE FACULTY OF THE
COLLEGE OF ENGINEERING.

Gentlemen:

This is the minority report on revision of the curriculum referred to in the report of Colonel Miller's committee of November 24.

The Department of Chemical Engineering dissents from the opinion of the majority of the committee as expressed in paragraph 2 which states that the majority of the committee had been unable to comprehend the necessity for a sequence in chemistry which would require chemistry to be taken by chemical engineers in the second year of the course. The technical subjects in the divisions of engineering repre-

sented by the majority of the committee are founded upon the two fundamental sciences of mathematics and physics. Members of the committee admit that they would not allow either mathematics or physics to be eliminated from the second year. The technical work of the Department of Chemical Engineering is founded upon three fundamental sciences instead of two. It is just as important that there be a sequence in chemistry for the chemical engineers as that there be a sequence in mathematics and physics for the other departments of engineering. This was the view of the faculty as shown by its action of June 2, 1922, which specifically excepted the chemical engineers from the uniform program of the first two years.

It is perhaps also worth noting that the chemical engineers did present a program which eliminated chemistry in the second year for the chemical engineers on condition that all of the engineers take two semesters of chemistry instead of one in the Freshman year. This was not agreed to by the majority of the committee. The report which Colonel Miller prepared showed that the University of Michigan has the lowest requirement in chemistry of all of the engineering colleges listed. No increase has been allowed to fundamental chemistry even in this revision which aims to broaden the course very decidedly.

Very truly yours,

(signed) ALFRED H. WHITE.

DISCUSSION.

Henry S. Jacoby: The six-year course has not had a fair chance. The tendency has been, apparently for administrative reasons, to crowd the technical subjects into the later years, separated almost completely from the arts subjects. Some cultural subjects should continue into the last year when the students are better fitted to appreciate their real value. Technical subjects like mechanical drawing, descriptive geometry, surveying, and elementary mechanics should be given in the earlier years so that in the middle years the study of cultural and real engineering subjects may proceed together.

Hugh Miller: At Rice Institute they give the A.B. in Architecture at the end of four years and B.S. in Architecture at the end of five years. It seems to me that they established one point, that the B.S. in Engineering is really a higher degree than the straight Bachelor's degree. At most institutions the

A.B. degree and the B.S. degree can be obtained at the end of three years. At George Washington University we require 140 semester-hours for a B.S. degree in the various branches of Engineering against 120 semester-hours for the A.B. degree. This agrees with the general practice in other institutions. Therefore our B.S. degree in Engineering is equivalent to practically two thirds of a year's more work than the straight Bachelor's work. Therefore let me ask the question; Why should one Bachelor's degree in our Universities require more hours than another?

A. M. Greene: The table presented by Dean Cooley and the distribution of time and subjects are in close agreement to that which we are planning at Princeton.

The engineering courses at Princeton for a number of years have consisted of an undergraduate four-year course leading to the degree of C.E., and a graduate course of two years leading to the degree of E.E. The graduate course is open to men holding bachelor degrees. For the last three years Princeton is offering five undergraduate courses leading to the degree of Bachelor of Science in Engineering and a fifth, or graduate, year leading to the technical degrees of C.E., E.E., M.E., and Ch.E. The total number of hours in the undergraduate courses is approximately 144, and if the fifth year is added, the total for the five years amounts to 180 hours. The distribution of work is practically the same as that given by Dean Cooley.

The Trustees of Princeton University desire to utilize its facilities by reducing the engineering work as much as possible in order that the students may take courses given in the other departments of the University, so that graduates may go out with a broad outlook. In the four-year course we have retained the fundamentals so that the graduate is prepared to enter the engineering world and do exceedingly good work, although his monetary value to an employer will not be as great for a few years as those trained under the standard four-year courses. We believe however that the training secured is such that after the experience of a few years in prac-

* Degree C.E., M.E., or E.E.

tice he will be equal to those trained according to the old plan, and will be better able to advance in the profession.

The fifth year is arranged so that special work is done in a particular field of engineering. The special technical courses omitted from the four-year course are now studied and we have arranged courses in specifications, contracts and engineering economics in which the student will work independently, reporting at weekly intervals to one of the Faculty staff with whom the work of the week will be discussed. This same method of study will also be extended to a technical elective and in one-third of the second term of this fifth year the student will work on a thesis which may be on a research problem or on a comprehensive design problem.

The course includes four term credits in economics and six term credits in electives and, as Dean Cooley has indicated, we endeavor to have the student select such subjects for these electives as will give him training so that he will enter the profession with aims which are not alone technical.

The degree at the end of the fifth year is the technical degree of engineering, while the degree at the end of four years is the bachelor's degree in engineering.

C. S. Howe: Some years ago Adelbert College of Western Reserve University and Case School of Applied Science organized a combined course of study under which a student attended Adelbert College for three years having little or no connection with Case, and then went to Case for two years having little or no connection with Adelbert. At the end of five years he was given degrees by both institutions. I am certain that both of these colleges looked forward with a great deal of interest to this course and were very hopeful that it would induce many young men who wished to study engineering to secure a part of a liberal training before entering upon scientific study. But the course has not been a success. Perhaps this has been due to the fact that the two institutions are entirely independent although upon the same campus. There is considerable athletic rivalry between the colleges and for this reason students have not cared to go from Reserve to

Case, especially if they were athletes and might be obliged to play against their former college friends. The numbers taking the course have steadily dwindled until now there are rarely more than one or two in any one class.

O. M. Leland: Much of the difficulty in attracting students to five-year courses in Arts and Engineering has been due, in my opinion, to the fact that, for the first two or three years of the course, the student is registered in the Arts College. The student who desires an engineering course does not like to be forced to spend a year or two in college without any engineering work at all. The psychology of the student is ignored in these cases and the result is that he does not take the five-year course as he would if it were entirely in the engineering college. Engineering students are proud of the fact that they are engineering students, and that their courses are more difficult than those in the arts college. Therefore, they should be given some engineering work from the very beginning of their college courses. The broad, cultural work should be taken in parallel with the technical work. The engineering work of a five-year curriculum should be distributed throughout the entire five years, and not concentrated in the last two.

Moved that the Chairman proceed to explain the chart which had been distributed.

Mr. Raymond: The charts that you have in your hands indicate in a very general way the result of the efforts of the faculty of the College of Applied Science of the State University of Iowa to formulate a five year course in engineering.

You will note that in this course general education is given 26 per cent. This includes English, public speaking, economics, accounting, business law, and elective courses in arts.

What we have called engineering preparatory subjects, of which 22 per cent. is included, includes mathematics, chemistry, physics, and mechanics. The 49 ½ per cent. of engineering subjects include the drawing, shopwork, surveying, heat engines, machine design, hydraulics, and the various special courses in civil, electrical, and mechanical engineering.

You will note one error in the diagram. The degree to be

given at the end of the fifth year instead of Master of Science in Engineering is to be a professional degree, civil engineer, electrical engineer, or mechanical engineer, according to the course pursued.

Our present intention, moreover, is to have the work of the three first years exactly alike except for 12 semester hours of electives in the third year; and the fourth year is alike through the first semester, except for five semester hours of electives. In the second semester there is a differentiation to the extent only of five hours, those who are to take electrical engineering electing electro-mechanics; those who are to take mechanical engineering, thermodynamics, and those who are to take civil engineering electing the theory of structures. The fifth year is to be a year of a high degree of specialization, there being 11 options offered: one an option in general engineering; four options in civil engineering, these being hydraulic engineering, structural engineering, sanitary engineering, and transportation engineering; three options in electrical engineering, and three in mechanical engineering. Throughout the course it is to be our effort to ground the students in the fundamental science underlying the practice of engineering.

I ought to say that this course has been actually adopted by the faculty of the College of Applied Science, and has been submitted to the governing board for its approval. The course will not be put into effect until this approval is obtained.

A. A. Potter: Have we any definite facts to show that the practitioners in law or in medicine are satisfied with the results secured from the increased length of preparation for their professions? The study by the Board of Investigation and Coördination should throw much light on the need for lengthening the curricula in engineering to five or six years.

Adjournment.

PROGRAM AND INFORMATION, MEETING OF DIVISION OF DEANS AND ADMINISTRATIVE OFFICERS, UNIVERSITY OF MICHIGAN, JANUARY 25–26, 1924.

ARTHUR M. GREENE, JR.,
Chairman.

FRIDAY, JANUARY 25, 1924.

10:30 A.M. Inspection of plant and work of Colleges of Engineering and Architecture, General Library, Clements Library, Model High School.

12:30 P.M. Luncheon at Michigan Union.

2:00 P.M. First Conference, West Engineering Building.
Length and Content of the Curriculum:
DEAN W. G. RAYMOND—The Iowa Plan.
DEAN H. J. HUGHES—The Harvard Plan.
DEAN M. E. COOLEY—The Michigan Plan.
DEAN G. B. PEGRAM—The Columbia Plan.
DEAN E. J. MCCAUSTLAND—The Missouri Plan.
PRESIDENT A. C. HUMPHREYS—The Stevens Plan.

6:00 P.M. Dinner at Michigan Union.

8:00 P.M. Chaliapin Recital at Hill Auditorium.

10:00 P.M. Smoker at the University Club.

Note.

The discussion of the important questions on the program will be of much greater value to all if each will bring to the meeting definite data regarding the various subjects under discussion, and the practices of his own institution.

SATURDAY, JANUARY 26, 1924.

9:30 A.M. Second Conference, West Engineering Building.
The Place of Research in the Engineering School, C. R. RICHARDS, President, Lehigh University.
The Relation of the Engineering School to the Industries, M. W. ALEXANDER, National Industrial Conference Board.

12:30 P.M. Luncheon at Michigan Union.

2:00 P.M. Third Conference, West Engineering Building.
Training for Activity in Non-Professional Matters.
The Work of the Board of Investigation and Coördination. CHARLES F. SCOTT, Chairman.

6:00 P.M. Reception at Michigan Union, Deans of Colleges and Engineering Faculty.

7:00 P.M. Banquet at Michigan Union.
Addresses: M. L. BURTON, President, University of Michigan; W. E. WICKENDEN, Director of Investigations.

REGISTRATION.

The registration desk will be in the lobby of the Michigan Union. Visiting Ladies will register here also.

ENTERTAINMENT.

The University of Michigan has generously provided the following entertainment for all those attending the conferences:

Friday, January 25.

8:00 P.M. Chaliapin Recital at Hill Auditorium.
10:00 P.M. Smoker at the University Club.

Saturday, January 26.

6:00 P.M. Reception at Michigan Union.
7:00 P.M. Banquet at Michigan Union.

ROOMS AND MEALS.

Expenses for meals and sleeping accommodations for one night in Ann Arbor will be approximately $7.50.

TRAINS.

Train for Detroit, Michigan, will leave Ann Arbor, Saturday, January 26 at 10.43 P.M.

Train for Chicago, Illinois, will leave Ann Arbor, Saturday, January 26 at 11:44 P.M.

City time given above is one hour faster than Central Time.

METHODS OF TEACHING ENGINEERING DRAWING.*

BY F. G. HIGBEE,

Professor of Descriptive Geometry and Drawing, State University of Iowa.

In order to make this discussion as pertinent as may be, I shall explain briefly what I consider the basic essentials in a course of engineering drawing, because I believe that in a discussion of this sort it is important to focus our attention upon the major divisions of our subject and limit ourselves to a consideration of the methods of teaching *these* elements of the course.

Every course in the fundamentals of engineering drawing should be planned on the assumption that the students who take it have had no previous training. For the few students whose previous training in drawing is discovered to be adequate, provision should be made preferably in a course of a more advanced character; but those students who have had a drawing course in high school will generally discover it worth while to enter and complete the basic course in college. Need I elaborate on this point in such a group? I believe not!

We will assume then that we are discussing a course in engineering drawing which may be undertaken successfully by students with no previous training and which may be taken with profit by most students who have dabbled in the subject in high school. What are the essentials of such a course? What broad divisions of the subject shall be considered?

First: I think you will agree with me that first, in point of the order in which it is taught at least, will come *the use of tools.*

Second: Next in order, and perhaps first in importance, will be what I call *shape description;* variously called also projection drawing, orthographic projection, etc.

Third: Following shape description in natural order will come *size description,* or dimensioning.

* Read at the first group conference of teachers of the subject, held in connection with the Ithaca convention, June 22, '23.

Fourth: Last in order of teaching is the *application* of the foregoing principles to practical drafting.

Now let me repeat at this point, that my discussion is to be limited and that in giving these four important and basic elements of an engineering drawing course, I would not have you infer that there are no other important divisions. I have made no mention of lettering, for example, for the reason that the subject of lettering alone deserves an entire conference; nor have I made any mention of the important specialized elements of a course in engineering drawing, such as, for example, architectural, structural, map drawing and the like which deserve and require special treatment. But I have confined my division of the course into three very basic and essential major divisions without a thorough grasp of which a student can make no progress, and a fourth division called the applications, which is intended in a general way to cover working drawings of all kinds.

Having thus established the four major divisions upon which, at this second conference of drawing teachers, we are going to focus our attention, let us now consider methods of teaching them.

Probably there is the least variation and the least difference of opinion in the method of teaching the use of tools. This is due largely to the fact that *practice* is the great teaching element; the teacher may explain in a general way, may instruct in an individual way, at the student's drawing board, may criticise and may supervise; all of these processes of instruction should be, and generally are, followed but after all practice is what makes perfect. The most important function the teacher exercises in this division of the subject is in the judicious and skillful selection of problem material, and in establishing a high ideal of workmanship in the student by searching and sympathetic criticism. Once the student is made to understand that he himself should be his own severest critic, and once he is confronted by a real and attainable high standard of draftsmanship, what remains is largely prac-

tice on the part of the student and sympathetic guidance upon the part of the instructor.

The teaching of shape description presents a real problem to teachers of drawing early in the course. Some teachers have solved this problem in one way, others in other ways; some colleges have arranged their courses in drawing so that at this point they can be coördinated with descriptive geometry, other colleges teach drawing and descriptive geometry parallel to each other, still others teach descriptive geometry first or at least in such a way as to make it possible for students to be given instruction in orthographic projection in that course in advance of the drawing, and still others,—and these are in the majority I believe,—teach drawing in advance of descriptive geometry and thus must give their students, in the course in drawing, instruction in projection. It is with this condition that I shall confine my discussion of teaching methods.

I think during my career as a teacher of drawing I have taught shape description under all of the above named conditions and many more! And I have yet to find the ideal method; the best I can say in defense of my present scheme is that it seems to work fairly well although I am not prepared to defend it on pedagogical lines.

In the first place, I believe there is something in calling this division of the subject "shape description," and explaining in simple language that it is a definite and reliable method of accurately describing the shapes of objects. Concurrently with this explanation it is well to add that having the shape of an object described you have the framework upon which to hang the size description, and having the shape and size of an object described you have, with a shop note or two, a working drawing. Approached from this angle the subject seems more agreeable and less formidable than when discussed as descriptive geometry, orthographic projection, etc.

In presenting the theory of shape description to students I have found that the amount of time it takes to explain and thoroughly drill students in orthographic projection is out of

all proportion to the results secured. The theory goes over their heads; and, while I have no other defense to offer than that the system works, I believe that empirical methods are justified in view of that fact that the real theory is taught during the subsequent course in descriptive geometry. Do not understand that I am advocating the omission of an explanation of the theory of orthographic projection from the course in drawing, on the contrary I believe this theory should be explained and, moreover, I practice what I preach, but I have taught long enough to know that precious few of the class absorb my teaching! As a result, I have placed more and more emphasis on a simple explanation of the arrangement of views and have drilled the class on this arrangement until it becomes fixed in their minds. They may not, and very likely do not, know much about *why* views are so related but, what is essential, they do know that they *are* so related, and that he who tampers with this arrangement will do his drawing over!

It should be remembered that during the period of time required to establish the principles of shape description, the student should be working on drawing board problems not only designed to fix these principles thoroughly in mind but also selected to give him a wide range of experience in handling his tools as well. In fact, the teaching of the use of tools will continue throughout the course and when planning a series of problems this point should be kept in mind.

Following shape description, the student is naturally led on to the study of size description, which is, to my way of thinking, one of the most difficult parts of drawing to teach. It is difficult primarily because, except for a few general principles, this part of drawing is not defined by regulations. Judgment, experience, and a knowledge of shop practices play much more important parts here than do rules, and these elements usually are lacking in the student at this stage of his training. The main reason why college drawings bear the stamp of amateurishness is because of a lack of understanding of dimensioning and what goes with it.

To be taught properly, this part of drawing must be studied with the fact in mind that no description of an object is adequate unless that description makes its reproduction possible. The basic principles of shop practice may have to be explained in the drawing room at this point, for students certainly cannot intelligently dimension drawings without such knowledge.

The successful teacher of drawing will give much attention to the character of the problems he selects for this part of his course, for it is in both the *graded* character of his problems and the range and variety of material they present that the student's judgment and experience in size description will be developed. The fact that any one object may be described as to size correctly in more than one way—or in more than one arrangement of dimensions—presents a pedagogical problem which often becomes serious, and a wise teacher will anticipate the doubt which indefiniteness always arouses in the minds of young students by explaining in advance that different draftsmen will describe the size of an object each by his own arrangement of dimensions, and that so long as no general rules are violated and the information is adequate and correct, each of these methods may be said to be satisfactory.

Too much emphasis can not be placed upon the importance of careful checking and criticism at this point of the course. The attitude of the student toward the importance of careful and reliable checking of drawings, and toward the necessity of having every finished drawing correct, will be strongly influenced by the attitude his instructor assumes.

The fourth division of a course in drawing, you will recall, is the application of the student's knowledge of the foregoing three divisions—the use of tools, shape description, and size description—to the making of practical working drawings. At this point in the drawing course a student should have received enough basic training so that emphasis may be placed upon the development of his skill in technical drawing relating to civil, mechanical, electrical, and architectural subjects. To be sure the teacher must never cease to expect and demand in this work high regard for the essentials of drafting: the

student's form and technic must be watched and criticized, and his shape and size description must conform to the principles already established, but the major part of the time devoted to this work should be directed toward perfecting the student in technical drawing.

Not much so far has been said concerning the machinery of the class room, or what has been called the mechanics of instruction. I have purposely deferred a discussion of this element in the teaching of drawing to the conclusion of this paper, because what I have to say on this matter will apply equally well to the four divisions under discussion.

Instruction in drawing may be, and is, usually conducted by one of the following plans:

1. The class meets in the drawing room and instruction is largely individual, and at the drawing table.

2. The class meets for stated lectures, or explanations once or twice a week and spends the remainder of the assigned time in the drawing room under supervision.

3. The class meets in a combined drawing and recitation room—or in a drawing room with a recitation or lecture room adjacent or nearby—and instruction is conducted as the need arises either in the lecture room or drawing room.

In all of the above cases "home work" may or may not be required.

I have had the good fortune, or misfortune, to teach under all three plans and I have come to the conclusion, that, while all of them have their own merits and demerits, the one listed as No. 2 is best, and I would like to conclude this discussion by stating that I am convinced that the best results in drawing will be secured in small classes—not over twenty-five—which meet not less than three times a week, twice for drawing and once for lecture, recitation or quiz; that each man should have a text book in which is carefully outlined the ground to be covered, and which is supplemented by complete notes of the problem requirements; and that all of the drawing room work in the course should be done under supervision.

PSYCHOLOGY IN DRAWING.

BY MORRIS WENK,

Assistant Professor of Mechanical Engineering, Oregon State Agricultural College.

Engineers must have ideas, imagination, mental pictures of roads, docks, railroads, irrigation works, machines, steamships, locomotives, every sort of engineering work to be built, not all at once or all in one brain, but in the profession as a whole. Engineers must be able to describe this picture in their minds, they must convey their ideas to others, and to do this must make use of means of communication. Facial expression, movements of body, speech, marks or characters may all convey ideas. The general use of the last of these is in special shaped marks called letters and special combinations of these letter marks into words. The characters called letters are accepted as indicating certain sounds and the grouping of them certain combinations of sounds. Thus the written character conveys the same idea as the spoken sound and these combinations of sounds or characters called words are accepted as the names of things, actions or qualities: that is spoken or written language. So spoken and written language is used to convey ideas, by reintegration of the things for which the words or sounds are symbols, but all specially shaped marks used in conveying ideas are not in the letter form. The Egyptian heiroglyphic and the American Indian sign characters use pictures as language characters,—use symbolism.

For the engineer the spoken or written language of ordinary intercourse is not sufficient. In some ways it is too cumbersome and in others it lacks the means to express his thought, so he has made use of a different set of characters, a different set of combinations of lines to convey his engineering ideas. The artist as well as the engineer uses combinations of

lines as his medium of expression but differs from the engineer in using color at times and perspective, both of which are hardly used at all by the engineer.

Both of these uses of combinations of lines are called drawing, pictorial for the artist, engineering for the engineer. For the engineer the drawing must be precise, accurate, so he generally uses instruments, from which it gets the name mechanical drawing and this kind is almost entirely orthographic drawing, which is a division of the mathematical subject, descriptive geometry.

Mechanical drawing is a graphic language requiring the fingers and arms in its use and not the lips and mouth. When neatly done by a skillful man it has an elegance and style comparable to other fine literature. Since it is a language, the psychology of speech with the proper adaptations to the muscular system, would seem to apply. As with a baby who has the capacity of speech born in him but who must learn to talk, so the engineering student has the capacity to make mechanical drawings born in him but must learn to do it.

The purpose of this paper is to examine somewhat the psychology of this learning to draw. The first words of a baby are imitations of words he hears his parents say, but before he can thus imitate the word he must have made the sounds for it himself. This is the purpose of the seemingly incoherent noise he makes, he is practicing in using the muscles of his lungs and throat.

He moves his arms and fingers in fantastic and apparently useless ways, but it is all practice. Then when an object comes near enough he reaches for it and is able to hold it. Having learned to grasp an object he is able to imitate his parent in holding a pencil and to further imitate by making marks with the pencil or anything which will mark—pencils, chalk, charcoal, etc.—on paper or walls or slates. Like the first vocal sounds, these first efforts with pencil are quite incoherent but soon he gets past this stage and the drawings take on resemblance to things about him. He is imitating ob-

jects about him, and in his imitation of the parent the child learns a great deal by the trial and error method.

So on up through the primary and secondary grades and high school the student in his work in drawing is largely imitating. His drawings are like objects or patterns he sees.

Let us consider the psychology of this imitation. Some say it is an instinct, that is, it is an unlearned pattern of behavior. This is doubtful and it is doubtful if a human infant which has never grasped an object could hold a pencil or piece of chalk.

Imitation is a stimulus-response situation where the response is the same as the stimulus, that is, every element in the response is identical with an element in the stimulus or as near as the individual can make it. In drawing in a school class these would be

Stimulus.	Response.
Paper	Paper
Pencil	Pencil
Pattern	Drawing
Instructor	Instructor

The child drawing by himself would perhaps not have a formal instructor but very probably would get something of instruction from parents or companions. In this we have a special case of conditioned response. The conditional stimulus is the direction to draw, with the elements, paper, pencil, and pattern as conditions—draw a particular pattern on paper with a pencil. The conditioned response is drawing, having as conditions the elements of a particular pattern, drawn on paper, in pencil, directed by instructor. The linkages between stimuli and response connect all items in one to their corresponding items in the other and the reintegration connects all items.

It may perhaps be of use to state what the term reinegration means. It is the phenomenon in which the presence of one or more elements in one situation will bring back into the consciousness completely another situation having the same element or elements. The greater the number of elements

common to both situations, the quicker and more vivid the coming back into the consciousness.

When, however, from experience in imitating drawings the student has acquired knowledge of a number of stimulus response situations in which the neurotic arcs from the eye sending the pattern to the neurones and through the synapses and neurones to the muscles of the fingers and arms are opened wider by use, and he may be said in common language to have acquired some manual skill; he may be given a problem to make a drawing which is not imitation.

As a simple illustration, suppose the student has been making a drawing of a regular hexagon of a given size, copying or imitating directly a drawing of the hexagon of the same size. He will be able to make this because he has built up his experiences from fantastic movements, as a baby through holding objects and imitating parents, and putting the lines to make a hexagon, he can because he has.

Now comes a new situation: he is given a sketch of a hexagon with size marked on it and in words is directed to put on a stem of a given size perpendicular to the middle of one side. There are then as elements of the old situation paper, pencil, shape of hexagon, size of hexagon, and the elements in the new situation are paper, pencil, shape of hexagon, different size of hexagon, stem position and size. The elements paper, pencil, and shape of hexagon are common to both situations and reintegrate the drawing of the first situation, to which the student adds the stem in its proper size, shape, and position. If the student had never seen or drawn a stem he would find it very difficult or impossible to draw this one.

With increased experience more and more of the exactly similar or identical elements in the two situations drop out and reintegration must be made from a few or only one common element as occurs when the direction for a new drawing is given in ordinary words and without any sketches, without pictorial symbols (which the sketches are). As an example suppose a student is given a written direction to make a drawing of a bracket bearing for a certain size shaft using metal

of a certain thickness in the casting and having the center of the shaft a certain distance from the base to be bolted to the support, and the bearing to be babbetted. If the student has never made a drawing of a bracket bearing or of any kind of a bearing or has never seen one, he would find it very difficult or impossible to follow the above directions even if he had skill in using drawing instruments and materials. Architectural draftsmen find it very hard to make drawings of machinery and the machinery man finds it hard to draw plans and elevations of buildings. The reason is there are not enough common elements in the two situations; there are no linkages over which reintegration may pass to connect up with previous experiences and carry them into the new situation.

The problem of drawing a bracket bearing was given to a class with the information outlined above but in the form of a drawing which they were to draw and trace to a different scale. Some members of the class who were not familiar with mechanical things found it difficult even to imitate the copy and one student who had never seen a babbetted bearing or had not paid attention enough to find out about one when he had unknowingly looked at it found it very difficult to understand what it was or to draw that part until the instructor showed him one and explained it. The trouble here was lack of common elements; they could not reintegrate knowledge or experience previously gained.

In facing the new problem they had nothing like it in previous problems which they could use to work by. Many students in another class had hard work making a drawing of the water end of a steam pump because they had never seen a pump or paid attention to one to get a mental picture of it. They could not reintegrate a situation which had no element common to a previous situation, no linkages between the situations. They had no foundation of previous experience to build on.

When, after years of practice, of trial and error, a man becomes an expert draftsman, the number of elements in his past experience becomes so large that any new situation which

may arise has many elements common to itself and the previous experience. He is called experienced because he can reintegrate so many elements. This large stock of memories, of elements, greatly facilitates forming mental pictures, trains and stocks his imagination and he can easily "see" the solution of the problem of the new situation and then reintegrate the muscular movements of fingers and arms to put the picture in his mind down on the paper in black and white. The experienced draftsman thinks implicitly. He has the mental picture without making marks on paper. Then when he transfers his mental picture to paper he reveals the fact that the whole operation of drawing is implicit. Drawing lines on paper or ink lines on tracing cloth melts no metal in the foundry, does not rivet up a boiler nor does it move earth for an irrigation canal or road. In the commercial case, the wish, the drive to the general stimulus situation is the customer's order, going through the whole organization: firm, chief engineer, chief draftsman, designing engineer, designers, draftsmen, detailers, tracers, blue printers, superintendents, foremen, workmen. The response situation is the reintegration by all these men of the elements in the new situation, brought about by the order, which are common to their experiences—are common to previous situations.

It has been asserted that psychology cannot teach how to teach. Perhaps. But if it cannot teach how to teach, it can at least teach us something about the learning process. The previous pages have dealt with the imitation by the infant and trial and error in his case and all through life. In imitation by the infant or child, there is the reintegration of pleasurable relations with the parent giving a positive affect to the situation and sight of the act of the parent as the stimulus and his response is to reintegrate previous situations where he made the same movements or some very much like them, he copies the movement as near as he can from his previous movements. In his later progress he must use the trial and error method.

Whatever the source of the stimulus there is some attempt to make a response. It may be inhibited or outrivalled. If

the first response does not satisfy the stimulus another is brought up outrivaling the first and so on until a consummatory response reduces the stimulus to quiescence. In education the remote general stimulus is the whole body of reasons why young people go or are sent to school and college. In the class room the immediate stimulus is the assignment of a lesson by the teacher or his directions for work in the laboratory, and the response is the satisfactory recitation or laboratory report or drawing, in all of which there are new experiences, new situations. Learning then is the acquirement of experiences in which responses have satisfied stimuli, and which can be reintegrated to save the time and loss of a wrong response, a response which might satisfy in one situation but not the one immediately at hand.

The art of teaching may be defined as the art of giving and withholding stimuli with the result of producing or preventing certain responses, using the word stimulus in a wide sense. Also the word response in a wide sense by it meaning any reaction made by the student, a new thought, a feeling of interest, a bodily act, any bodily or mental condition resulting from the stimulus. The aim of the teacher is to produce desirable and prevent undesirable changes in human beings by producing and preventing certain responses.

In the subject of drawing one important way of giving a stimulus is for the teacher to draw some of the problems in the presence of the student and so give him something to imitate of a more personal nature than a printed figure in a book. A serious trouble with students in lettering is that they imitate themselves instead of a good copy, that is they reintegrate the bad part of their previous experiences rather than getting a new element of making correctly shaped letters. The teacher can help correct this by making a correctly shaped letter and have the student go right over it. Having once made a letter correctly he can do it again. Of course he cannot do it with facility until after a good deal of trial and error experience, but he does have something to reintegrate which is an important step forward.

President Garfield said that Mark Hopkins at one end of a log and a student at the other constituted a university. What was the bond between the two? Teaching, that is the bond, teaching wherein is knowledge as the firmer structure and character, personality, enthusiasm, patience as the subtle essence. The student shall learn, the teacher shall teach; he shall share his life with the student.

A good teacher is one who knows his subject, a mile for every inch he tries to teach, he has a genuine conviction that his subject is a useful contribution to the advancement of civilization—there is some point to it. He has the art of getting his students interested in the subject, which perhaps is the essence of the subtle bond between the student and Mark Hopkins on the log; he has the respect of his students outside of the class room and also the respect of the community. One author writes: "Success in teaching can be properly measured by the skill the teacher has in developing interest in the mind of the student."

In psychological terms the teacher must have a large number of the elements of drawing stored away in his experience and memory which he can reintegrate as examples for imitation by the student so as to save time in trial and error methods. He must have a very strong favorable affect for the subject. He can give powerful stimuli to do work and the formation of a favorable affect by praise of the good and a powerful inhibiting stimulus—a negative affect for poor work by proper criticism, he will stimulate the formation of good habits in drawing, of following the best practice in the art, he will produce a favorable affect by firing the imagination of the student by giving him a vision of himself as a successful engineer and another help to the favorable affect will be his character and high standing in the community.

Arousing the interest of the student in the subject, getting a favorable affect to it in him and having him get pleasurable experiences in his work are perhaps the things a teacher should strive most earnestly for in his work as an educator. They are worthy of his best endeavors.

CORRELATION COEFFICIENTS BETWEEN VARIOUS ENTRANCE CRITERIA AND SCHOLASTIC COLLEGE PERFORMANCE AT IOWA STATE COLLEGE.

BY EDWIN KURTZ,

Assistant Professor of Electrical Engineering.

The steady increase of attendance in nearly all engineering schools will keep alive for many years research to determine the most reliable means of predicting at time of entrance the future scholastic college performance of the student. Much excellent work has already been done by Committee No. 22 on "Intelligence Tests" of the S. P. E. E. and their findings to date have been published in the January 1923 issue of the Journal. The writer has just completed a study of the Correlation Coefficients between high school grades, intelligence test scores, and the three year college average for the June engineering graduates at Iowa State College; and thinking that the findings may be of interest to teachers generally and to others making similar studies at their respective institutions, the findings have been summarized and are given below.

Norms.—One of the necessary steps in the computation of the Pearson Correlation Coefficient is the calculation of the norm or average grade for each group of data, in order that the positive and negative deviations can be found. The values of the norms as computed for the 46 seniors are given in Table I, where comparisons are also made with the norms of the 6,000–7,000 group of Committee No. 22, and the 272 Iowa State College Freshmen.

This table shows clearly what one would expect, namely, that those students who survive the weeding process of the undergraduate years should be the better students and should

therefore have higher test scores than the entire freshmen class which is made up of both good and poor students.

TABLE I.

COMPARATIVE NORMS.

S. P. E. E. Tests.	6,000–7,000 Freshmen.*	272 I. S. C. Freshmen.*	46 I. S. C. Seniors.†
Arithmetic	10.5	12.1	13.91
Algebra	4.3	5.9	7.3
Geometry	8.4	——	——
Physics	10.6	12.5	15.2
Tech. Inform.	62.5	67.5	70.0
Army Alpha	88.8	——	98.2

HIGH SCHOOL GRADES.

Average (4 years)	89.5
Math Group	90.4
Natural Science Group	90.3
English Group	88.2
Foreign Language Group	87.7
Social Science Group	89.5
Commercial and Industrial Group	90.8

COLLEGE GRADES.

Average (3 years)	86.5

Correlation Coefficient.—The values of the Pearson Correlation Coefficients between the high school group averages, the intelligence tests scores, and the three year college average are shown in Table II where comparisons are also made with the coefficients as found by Committee No. 22 for the entire freshmen group of 6,000–7,000 freshmen and first year college scholarship.

In general the coefficients are higher, there being increases for seven cases and decreases for only two cases. The most

* Data taken from report of Committee No. 22 published in January, 1923, S. P. E. E. Journal.

† Senior class consisted of 140 members, but only 46 of the class took the tests when given the first time, May 15, 1920.

significant increases are those for the Alpha Test 63 per cent., High School Average 48 per cent., Technical Information 49 per cent., English 37 per cent., and Natural Science 29 per cent.

TABLE II.

COMPARATIVE CORRELATION COEFFICIENTS.

S. P. E. E. Tests.	6,000–7,000 Freshmen.†	46 I. S. C. Seniors.
Arithmetic	.38	.354
Algebra	.42	.40
Geometry	.30	——
Physics	.34	.368
Tech. Inform.	.23	.343
Army Alpha	.29	.473
HIGH SCHOOL GRADES.		
Average (4 years)	.29	.428
Math Group *	.29	.338
Natural Science Group *	.325	.418
English Group *	.27	.37
Social Science Group *	——	.30
Commercial and Industrial Group *	——	.261
Foreign Language Group *	——	.343

The coefficients for the Army Alpha and the High School Average are the highest. This may be accounted for by the fact that although an engineering course is largely technical, a broad general intelligence is the best basis for success.

The writer realizes that while the results can not be taken as conclusive owing to the small number of students in the group, the results are valuable, however, in indicating the extent of possible variations from the average.

* The coefficients for high-school grades in the Committee No. 22 report are only for subjects, but are being compared with coefficients for groups of subjects.

† Data taken from report of Committee No. 22 published in January, 1923, S. P. E. E. Journal.

PURDUE BRANCH.

Meeting called in order to consider the Organization of a Purdue Branch of the Society for the Promotion of Engineering Education.

For some time certain members of the engineering faculty have felt the need of a branch chapter of the S. P. E. E., at Purdue University, since such a large number of its teachers were already members.

Accordingly at the invitation of Professor J. D. Hoffman, Head of the Department of Practical Mechanics, a meeting was held in the Civil Engineering Building. This was not restricted to simply engineering teachers, but was made broad enough to include all those who came in contact with engineering students.

The suggested subject of discussion read as follows:

Educational Waste.

Industry has recently been subjecting itself to a critical analysis regarding industrial wastes, avoidable and unavoidable.

Perhaps educational institutions and processes should be examined quite as closely to discover the extent of the wastes, avoidable and unavoidable with which we have to contend.

Definition.

"By waste is meant the expenditure of time, money or energy without adequate return."

The discussion ceased at 8:30 P.M., at which time Professor Hoffman, acting as temporary chairman, called the meeting to order and in a few well-chosen words explained that if a branch was formed officers should be elected.

Accordingly, after the usual procedure Professor S. D. Chambers was made Chairman and Professor J. A. Needy, Secretary.

Professor Chambers is Assistant Professor of Applied Mechanics, while Professor Needy is Assistant Professor of Mechanical Engineering.

The New Chairman upon assuming his duties thought it would be wise to know the conclusions drawn as the results of the discussion. Apparently no conclusions had been reached though the discussions had been rather extended.

Synopses of the Group Discussions.

Professor Munro spoke about the careless habits of students in regard to their waste of time and to improper habits of eating and sleeping.

Professor Greiner wondered if it were possible to increase the size of sections, thus reducing expense and cutting down the educational waste.

Dean Potter gave the results of such a trial at the "Massachusetts Institute of Technology" and stated that at that institution the mass system of lecturing to a large group of students had been given up and the old method of small sectioning had been adopted.

The meeting adjourned at 9:15 P.M., having been in session about 2 hours and 15 minutes.

John A. Needy, *Secretary,*
Assistant Professor of Mechanical Engineering.

ADDRESSES UNKNOWN.

Mail sent to the following members at the addresses appearing after their names has been returned. If you know the present whereabouts of these members, please communicate at once with the Secretary, Dean F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Andros, S. O., Chicago, Ill.
Avram, M. H., New York University.
Boerchel, W. H., Georgia School of Technology.
Bray, H. C. C., New Glasgow, N. S.
Carroll, H. H., Tufts College.
Ford, H. C., Iowa State College.
Furia, J. J., College of the City of New York.
Goldsmith, Adolph, Massachusetts Institute of Techanology.
Jones, F. R., 111 Broadway, New York City.
Lawrence, C. W., University of Southern California.
Lawton, E. E., Syracuse University.
Morrill, J. B., Palo Alto, Calif.
Pence, W. D., Chicago, Ill.
Turley, O. J., Washington, D. C.
Whitmore, R. D., New Rochelle, N. Y.

BOOK REVIEWS.

Power Plant Machinery. Vol. 1. Mechanism of Steam Engines. W. H. JAMES AND M. W. DOLE. 277 pp., 244 illustrations. John Wiley & Sons, 1923.

The kinematics of the steam engine is considered very fully, with valve gears described at length. There are sections on velocity of crosshead, indicators and indicator diagrams single value engines, ported and balanced valves value ellipse, Zeuner's diagram, Reuleaux diagram, Bilgrim diagram, typical examples of slide valve engines, port calculations, governing devices for single-valve engines, riding cut-off valves and their governing devices, multiple valve engines.

Stepheson link, Walschaert valve gear, Young valve gear, Baker valve gear, etc., setting valves description of steam turbines and governing mechanism including stop governors. There is an appendix of some 80 practical problems. Various worked examples throughout the text illustrate the subject matter very clearly. The work is free from difficult calculations.

W. F. W.

Elements of Machine Design. Second Edition, Thoroughly Revised and Enlarged. DEXTER S. KIMBALL AND JOHN H. BARR.

In presenting this revised edition, the writers have dealt with their different subjects simply and directly, avoiding on the one hand, explanations obvious to any student of fair capacity, and, on the other hand, subtle distinctions and discussions suited to more advanced work.

Consistent throughout the entire book, it will be found that the fundamentals alone are considered, allowing the student to apply his specific problem, and base the necessary reasoning for the solution upon the fundamental principles as

are given in the text. This is especially true of the chapter dealing with the design of machine frames and attachments. Here alone the basic principles of the theoretical design are discussed, thus allowing the student to reason for himself the practical, economical design of such machine elements.

F. H. S.

Elements of Engineering Thermodynamics. J. A. MOYER, J. P. CALDERWOOD, A. A. POTTER. Second Edition 1923. John Wiley & Sons. 224 pp., 75 illustrations, 11 tables, Heat-Entropy Chart.

Contents.—Thermodynamic Principles and Definitions. Properties of Perfect Gases. Expansion and Compression of Gases, Cycles of Heat Engines using Gas, Properties of Vapors, Entropy, Expansion and Compression of Vapors, Cycles of Heat Engines using Vapors, Flow of Fluids, Applications of Thermodynamics to Compressed Air and Refrigerating Machinery.

At the end of each chapter is a set of problems; each new thought and formula is satisfactorily explained with a worked example wherever possible. The appendix contains useful tables with a selected bibliography of engineering thermodynamics.

As stated in the preface the intention is to bring out the fundamental principles of engineering thermodynamics and for use of colleges giving special courses in steam turbines, internal combustion engines, refrigeration.

W. F. W.